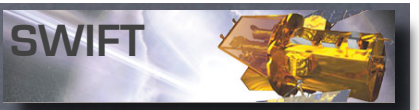
Fermi Symposium 2011



Properties of Supergiant Fast X-ray Transients as observed by *Swift*

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SFXTs in brief

- HMXB (re)discovered by INTEGRAL:

  TRANSIENTS: flares peaking at $1E^{36}$–$1E^{37}$ erg s^{-1} lasting hours as observed with IBIS/ISGRI (Sguera+ 2005, 2006)

- flare X-ray spectrum ~ accreting NS
- a few SFXTs are X-ray pulsars
- large X-ray dynamic range (3-5 oom)
- association with OB supergiant companions

Transient X-ray emission (outbursts shorter than in Be/X-ray binaries)

+ OB supergiant companion (HMXBs with supergiant were known to be persistent X-ray sources!) make these sources a NEW CLASS of HMXBs

Sidoli 2009 (AdSpR, 43, 1464)

- possible counterparts at GeV (Sguera+ 2009)

The *Swift* SFXT Project

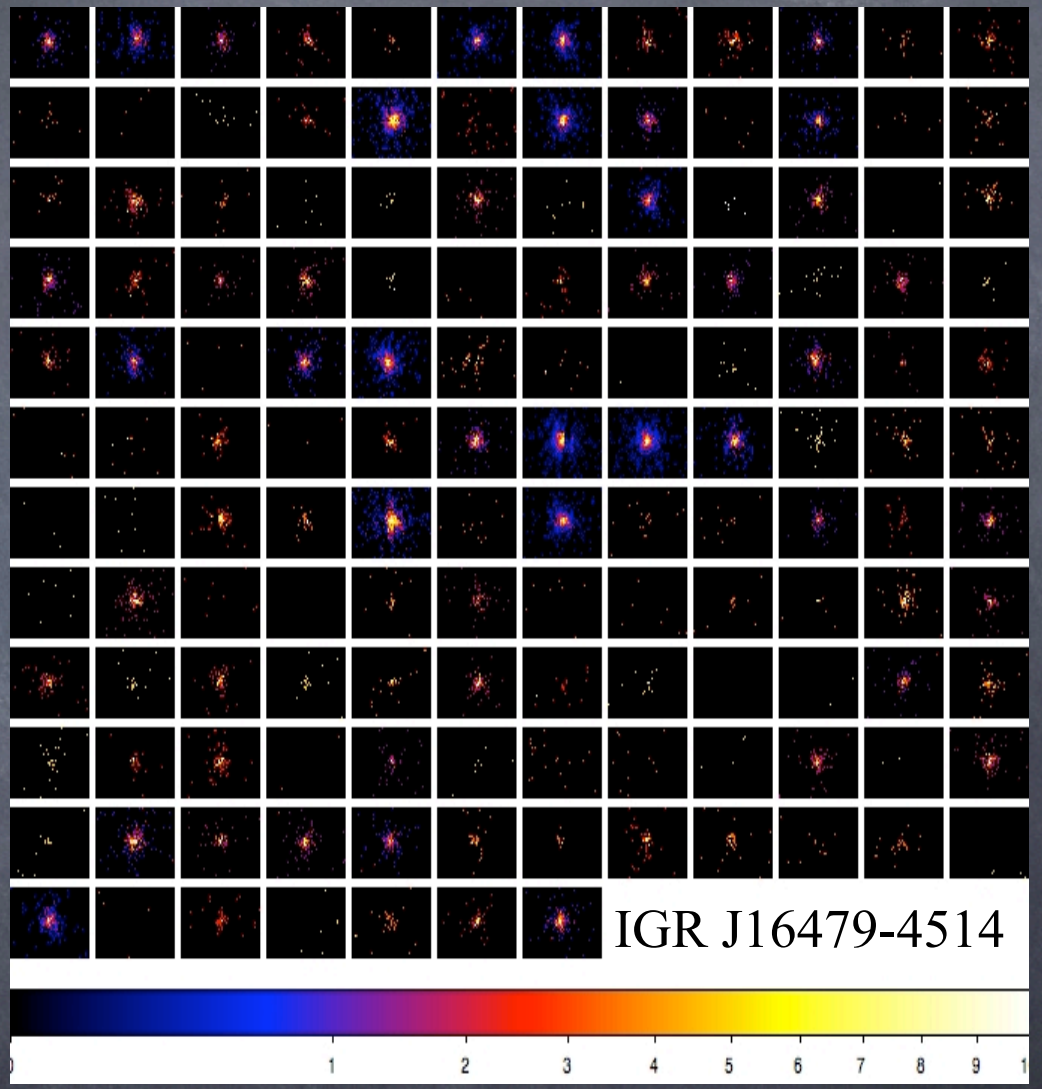
Fast & Panchromatic (~100s):

- ✔ true outburst length
- ✔ broad-band spectroscopy

Monitoring program:

non-serendipitous study in ≠ intensity states

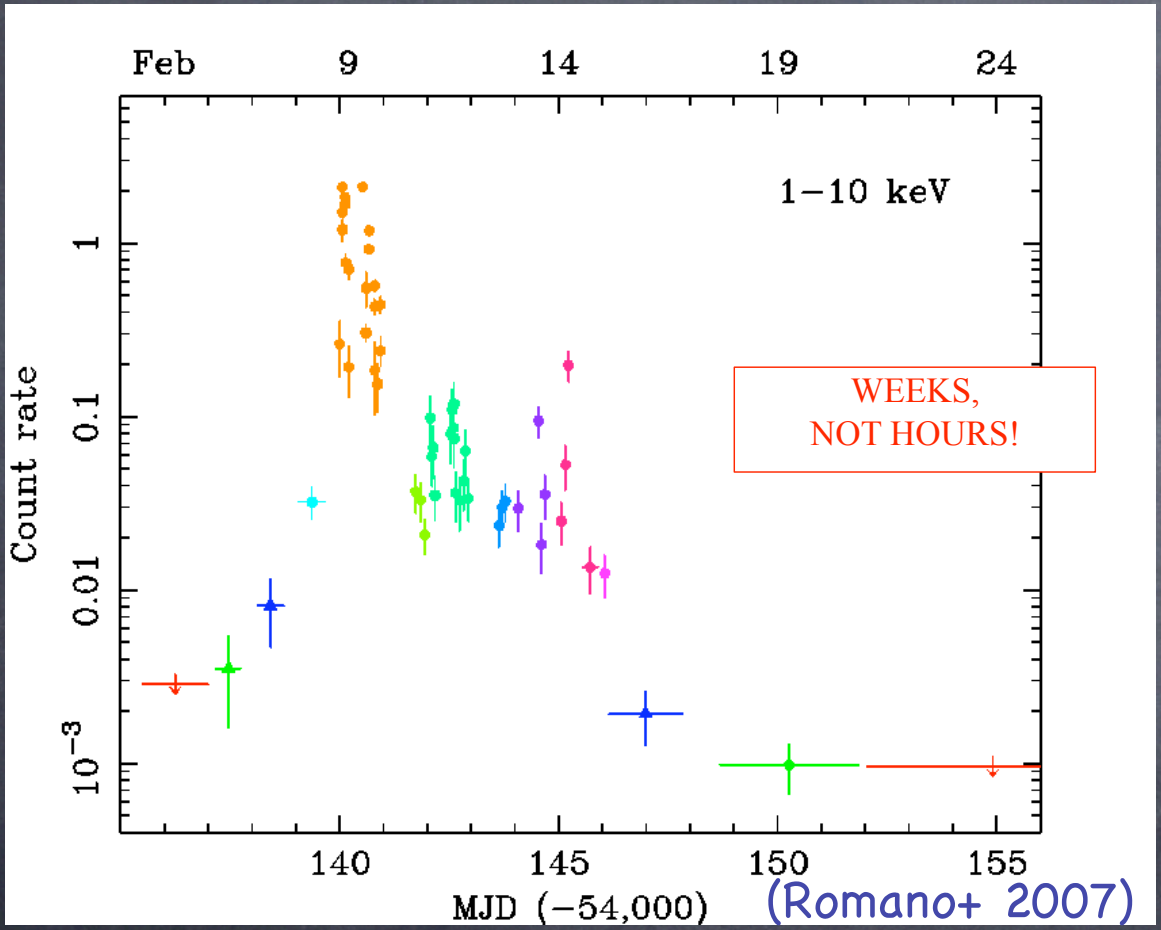
- ✔ different kinds of outbursts
- ✔ assessment of phases
- ✔ inactivity duty cycle
- ✔ intensity-based spectroscopy



(Romano+2011c,arXiv:1103.6036)

http://www.ifc.inaf.it/sfxt/

True outburst length: IGR J11215-5952



P_{orb} from Swift/XRT!

-Below detectability
$L(1\text{-}10) = 3.7\times10^{33}$ erg s^{-1}

-Slow rise

-Outburst (1day)
Feb 09: CR increase
by ~10 in <1.5 h
by ~65 in 17 h
$L(1\text{-}10) = 1.1\times10^{36}$ erg s^{-1}

$\Gamma \sim 1$, $N_H \sim 10^{22}$ cm^{-2}

-decline phase (5d)

-down to (15 d)
$L(1\text{-}10) = 1.2\times10^{33}$ erg s^{-1}

✔ SFXT $Lx \sim 10^{36}$ erg s^{-1}
dynamic range $\sim 10^3$

The *Swift* campaign

Sample: of 4 confirmed SFXTs

IGR J16479-4514 144 obs/161 ks

XTE J1739-302 184 obs/206 ks

IGR J17544-2619 142 obs/143 ks

AX J1841.0-0536 88 obs/96 ks (2008)

Total Exposure 606 ks / 558 observations

Sidoli+ 2008 (ApJ, 687, 1230)
Romano+ 2009c (MNRAS,399,2021)
Romano+ 2011a (MNRAS,410,1825)

2 or 3 obs /source/week, 1 ks each (Oc 2007-Nov 2009)

✔*BAT Special Functions* (for ALL known SFXTs and candidate)

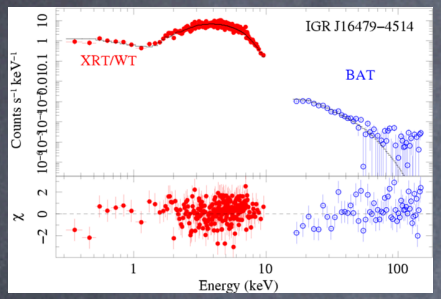
✔catch outbursts & follow them until source undetected

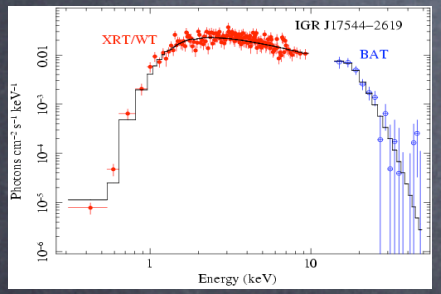
✔monitor long term properties (1st time) and towards quiescent level

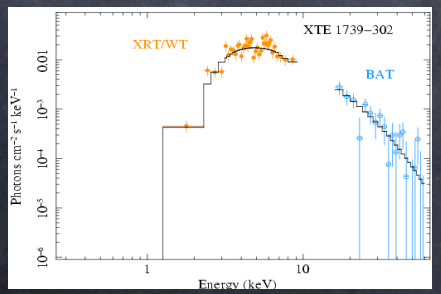
Outburst emission spectroscopy

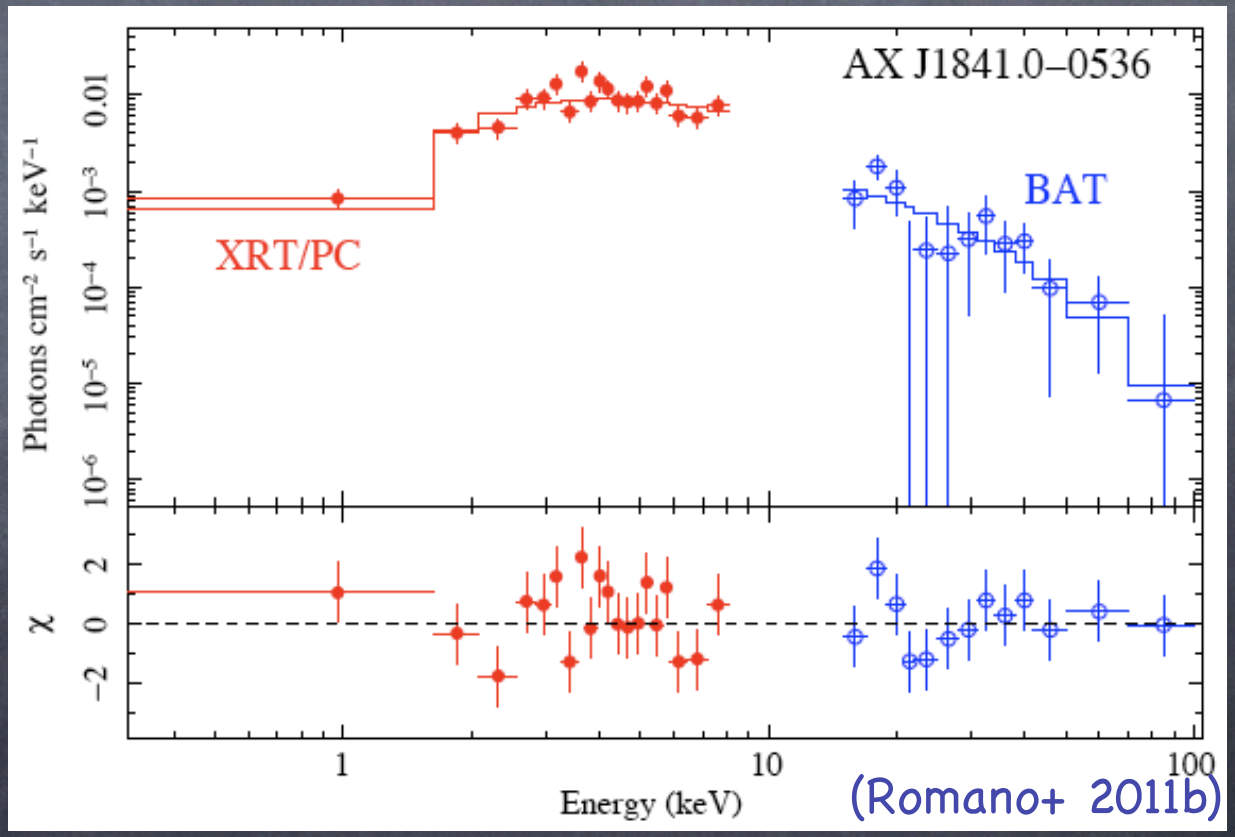
Broad-band spectroscopy
0.3-10 keV + 15-150 keV

✔absorption & spectral cut-off
✔comparison with models for accreting NS



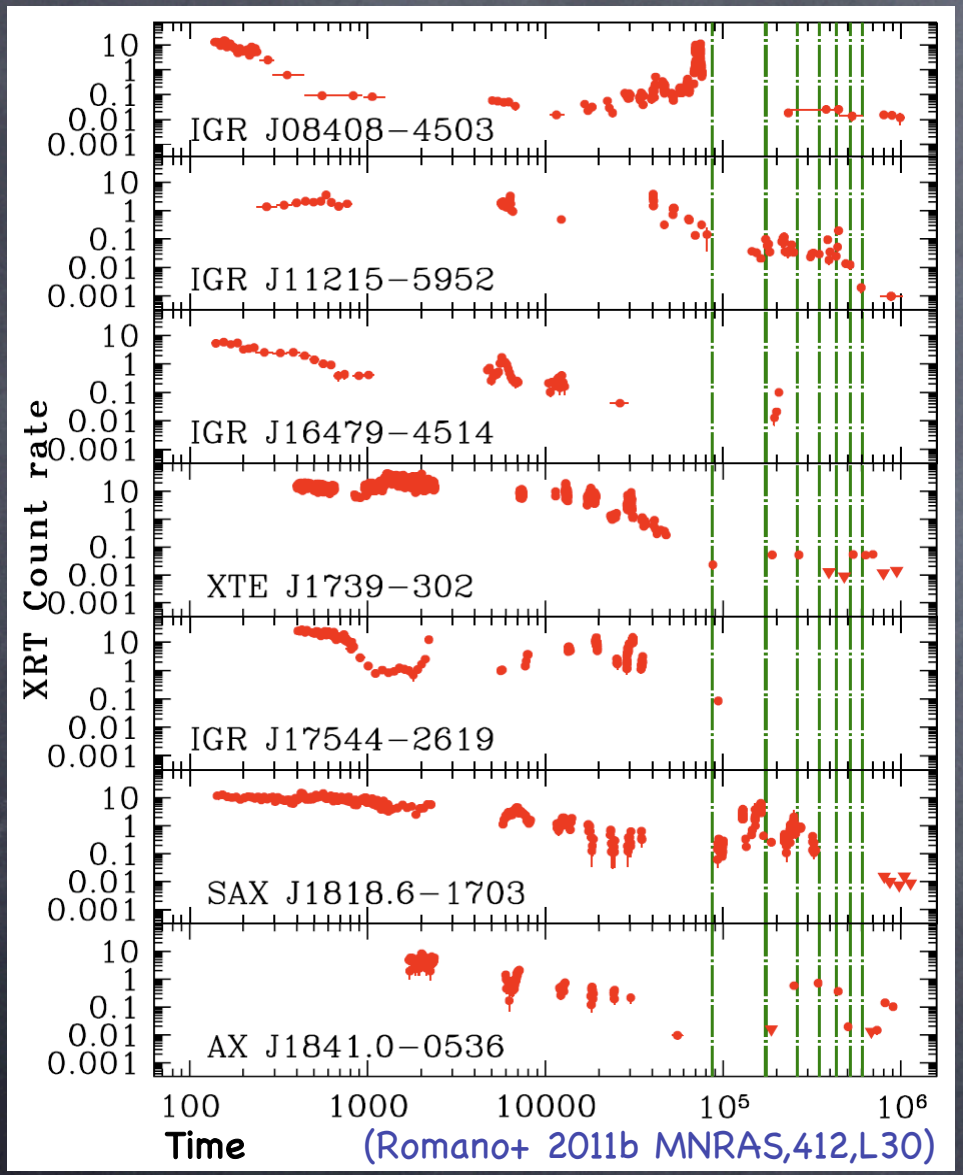






(Romano+ 2011b)

Outburst light curves



(highest timing resolution)

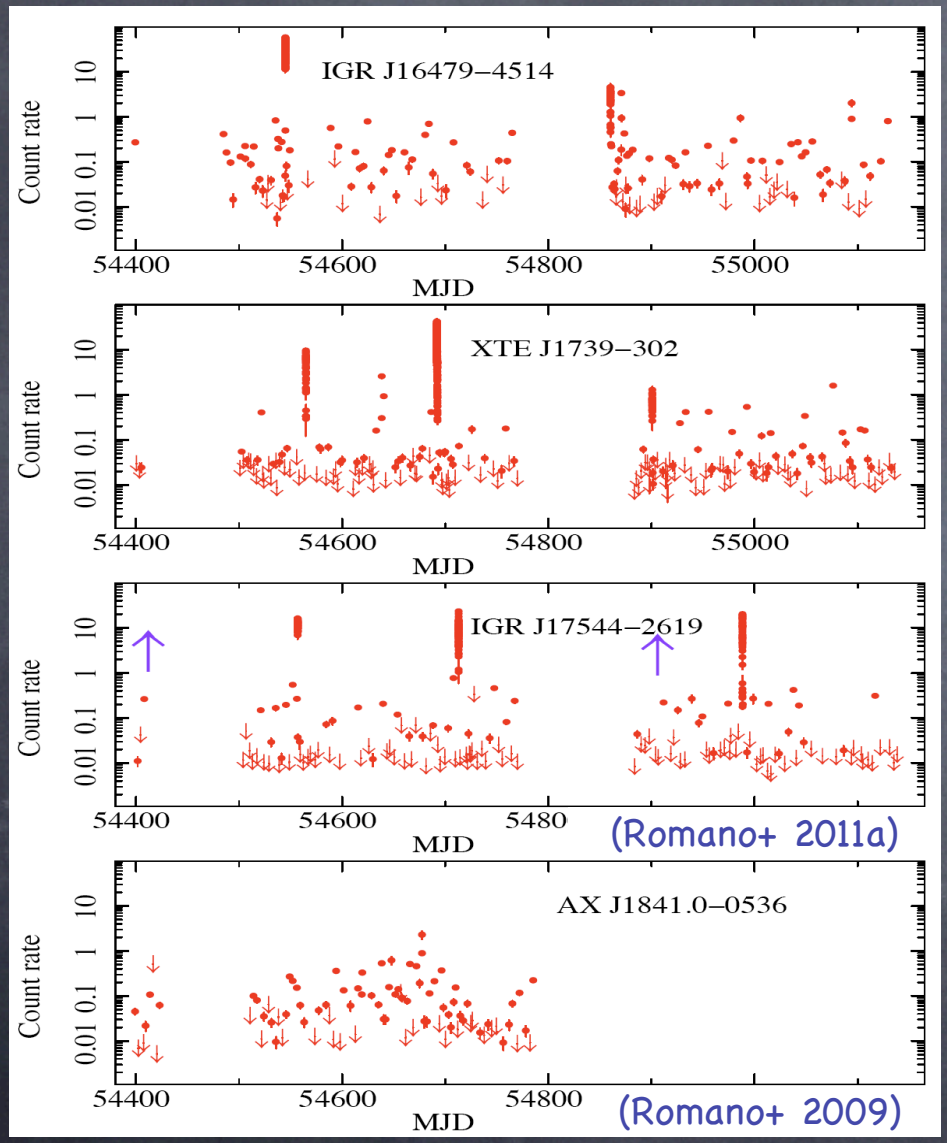
Common features:

✔outburst length > hours

✔multiple peaked structure with lots of flares

✔dynamic range: 3 orders of magnitude

Long term monitoring



2007-10-26
to
2009-11-03
(daily resolution)

✔dynamical range:
4 orders of magnitude

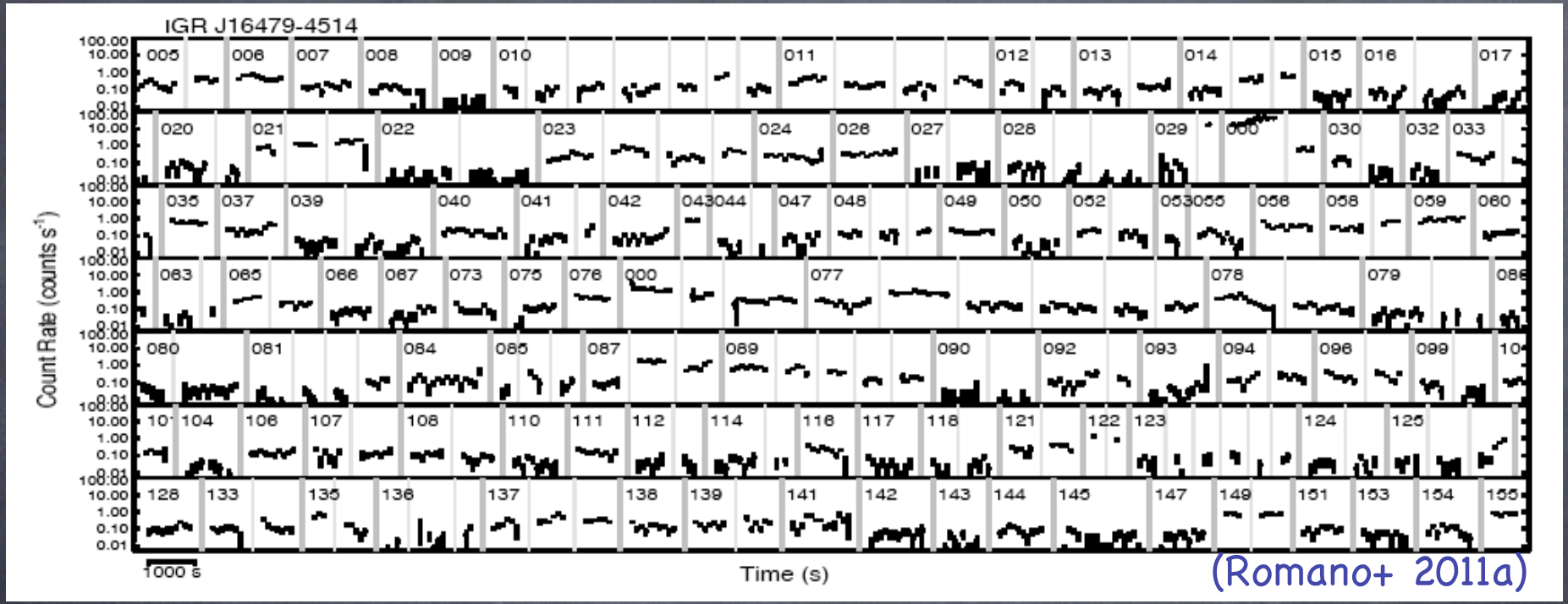
✔8 outbursts (+1!!!)

✔Emission outside of outbursts

✔variability:
days to months

Variability in *Swift*/XRT light curves

highest resolution: PC: 100s, WT 20s



(Romano+ 2011a)

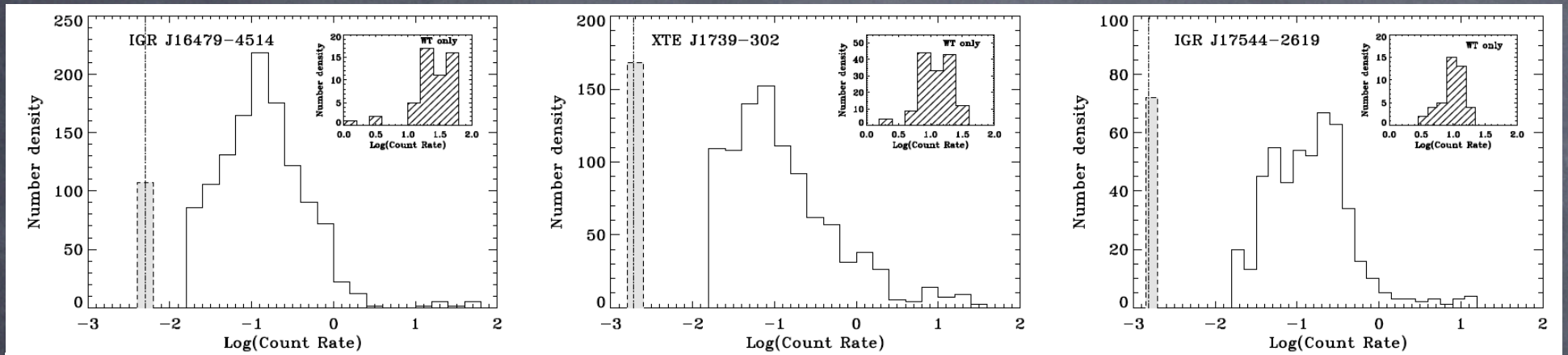
✔variability observed on all timescales and intensity levels ➔

✔short timescales 1 order of magnitude (1 ks, down to 0.1 counts s^{-1}) using Walter+(2007)

$$M_{\rm cl} = 7.5 \times 10^{21} \ (L_{\rm X,36})(t_{\rm fl,3ks})^3 \ {\rm g}$$

clumpy winds with clumps of 10^{18-19} g (Romano+ 2011a)

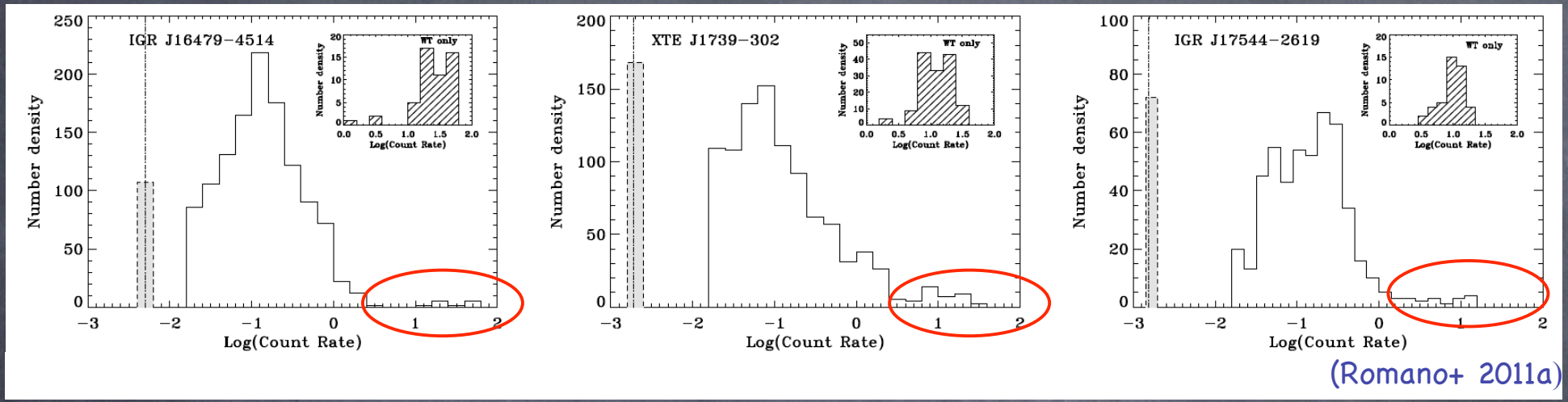
Swift/XRT Count Rate Distributions



(Romano+ 2011a)

- ✔ 3-5% of time spent in bright outbursts
- ✔ Most probable observed flux: 1-2x10^{-11} erg cm^{-2} s^{-1}
  (2-10 keV, unabsorbed) so that
- ✔ long term behaviour is intermediate state of accretion
  $L \sim 10^{33} - 10^{34}$ erg s^{-1}

Swift/XRT Count Rate Distributions



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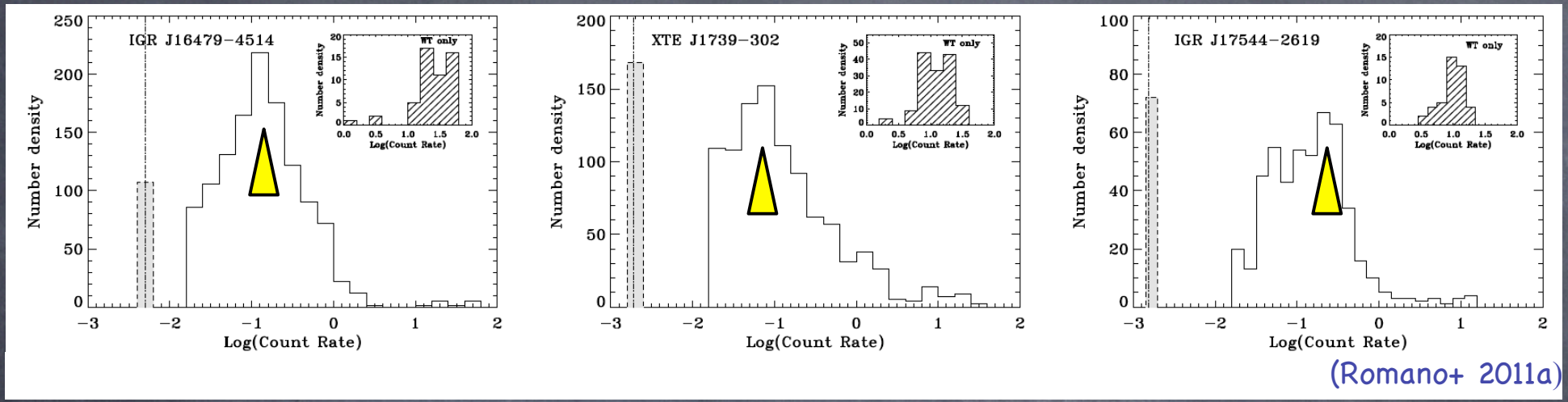

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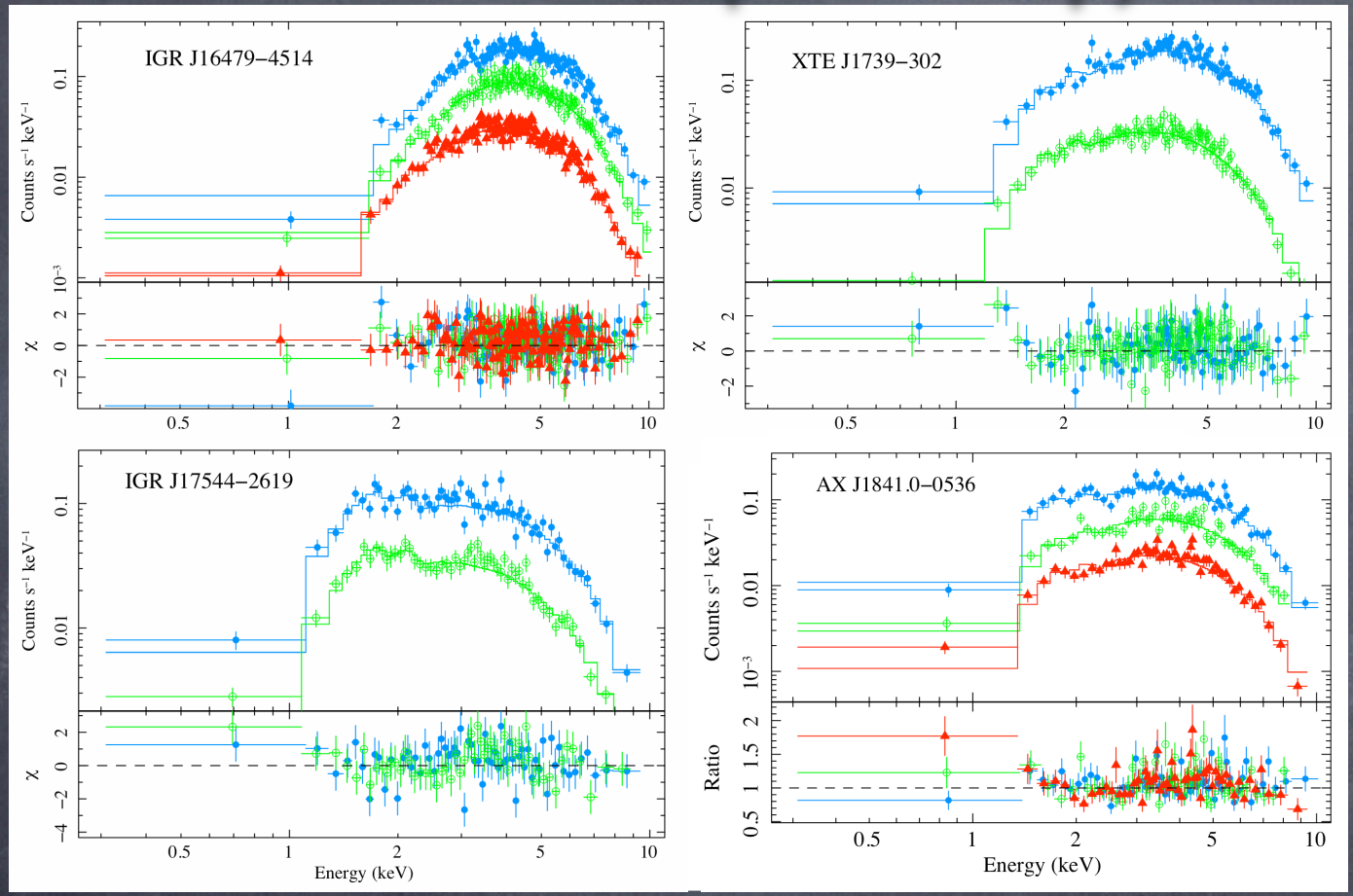
Out of Outburst spectroscopy



(Romano+ 2009c, Romano+ 2011a)

hard power-laws ($\Gamma \sim 0.8$–2)

$L_X \sim 10^{33}$–10^{34} erg s^{-1}

✔ accretion over several oom in Luminosity

The lowest luminosity level we could reach with *Swift*:
Lx = 4×10^{32} erg s^{-1} in XTE J1739-302, Lx = 3×10^{32} erg s^{-1} in IGR J17544-2619
incompatible with sperically symmetric steady wind ➔ clumpy wind.

Inactivity Duty cycle

(Romano+ 2009c,2011a)

XRT provides casual sampling of the light curve at a 4d resolution

- -BAT-detected outbursts,
- -intermediate state (firm detection excluding outbursts),
- -non detections (detections with a significance below 3σ).

$$\mathrm{IDC} = \Delta T_{\Sigma} / [\Delta T_{\mathrm{tot}} \, (1 - P_{\mathrm{short}})]$$

IGR J16479-4514	19%
AX J1841.0-0536	28%
XTE J1739-302	39%
IGR J17544-2619	55%

time a source spends undetected down to a flux 1-3x10^{-12} erg cm^{-2} s^{-1}

ΔT_{Σ} = total expo(>900s) where 3σUL only obtained;

ΔT_{tot}=total expo

P_{short}=%(expo < 900s)

✔Accreting matter most of the time

Conclusions

Fast & Panchromatic
- ✔ true outburst length
- ✔ broad-band spectroscopy

Monitoring programs
- ✔ outbursts
- ✔ assessment of phases
- ✔ inactivity duty cycle
- ✔ intensity-based spectroscopy

Fermi: an intriguing possibility

Swift SFXT Project
http://www.ifc.inaf.it/sfxt/

Contact point:
romano@ifc.inaf.it

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Thanks!